A nucleation-based mechanism for protein localization in bacteria

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***Short Abstract* — Recent research has highlighted several examples wherein bacterial cell fate is determined by precise subcellular localization of proteins. A prominent example is the polar localization and oscillation of the Min proteins which is necessary for accurate cell division in *Escherichia coli*. Several computational models have been proposed which reproduce the oscillatory behavior and observed phenotypes. However, these models use varying assumptions to do so leading to different mechanisms for precise polar localization of MinD zones. To gain further insight, we extend a simplified model which focused on some key processes to explain the observed length scale for MinD zone formation. In particular, we focus on the role of nucleation in precise polar localization of MinD. We explore cellular MinD distributions produced by the processes modeled and how localization patterns change as key parameters are varied.**

***Keywords* — cell division, Min protein oscillation, localization, nucleation**

I. Introduction

RECENT research has drawn increasing attention to mechanisms of precise subcellular localization of proteins in bacterial cells. In the process of *E. coli* cell division, the location of the division septum is known to be governed by FtsZ ring formation [1] and the placement of the FtsZ ring is regulated by the Min protein system [1-5]. Three Min proteins, MinC, MinD, MinE undergo rapid pole-to-pole oscillations to block FtsZ ring formation at the cell poles with a period of about 40-60s [6-9] and therefore avoid minicelling. Filamentous *E. coli* cells also display Min protein oscillations and the new MinD zones are observed to be located in between the two adjacent MinD old zones [10]. Several numerical models with varying assumptions have been developed which successfully reproduce the oscillations of Min proteins. However, key questions relating to the mechanism for precise polar localization of MinD zones remain.

II. Results

We extend a previous 1-D model to explain the length scale for MinD new zone formation in finite cells. The key elements we consider are the processes of diffusion, nucleotide exchange, membrane attachment and attachment nucleation contribute to the specific MinD localization in the cell. We examine how the integration of simplified models for each of these processes provides an understanding of protein localization in the system. Within our model, we show (using analytical approach and simulation) how the nucleation can plays a key role in reproducible and precise polar localization of proteins in bacteria, and how localization patterns change as key parameters (e.g. cell length, mean nucleotide exchange time) are varied.

III. Conclusion

The Min proteins sub-cellular localization in *E. coli* cell division is governed by physical processes. Using simplified models for these processes, we explore the specific localization of MinD to polar zones as key system parameters are varied. Based on our results, we propose a more general nucleation-based mechanism for protein localization in bacteria.

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